



BILFINGER

Babcock Noell GmbH

Superconducting Flywheels – Rotating for Stability

Impulse on Superconducting Hackathon

Babcock Noell GmbH

CERN, September 22nd, 2017

Flywheel

When was the flywheel invented?



The principle of the flywheel is founded on the Neolithic spindle and on the potter's wheel.



6500 B.C.




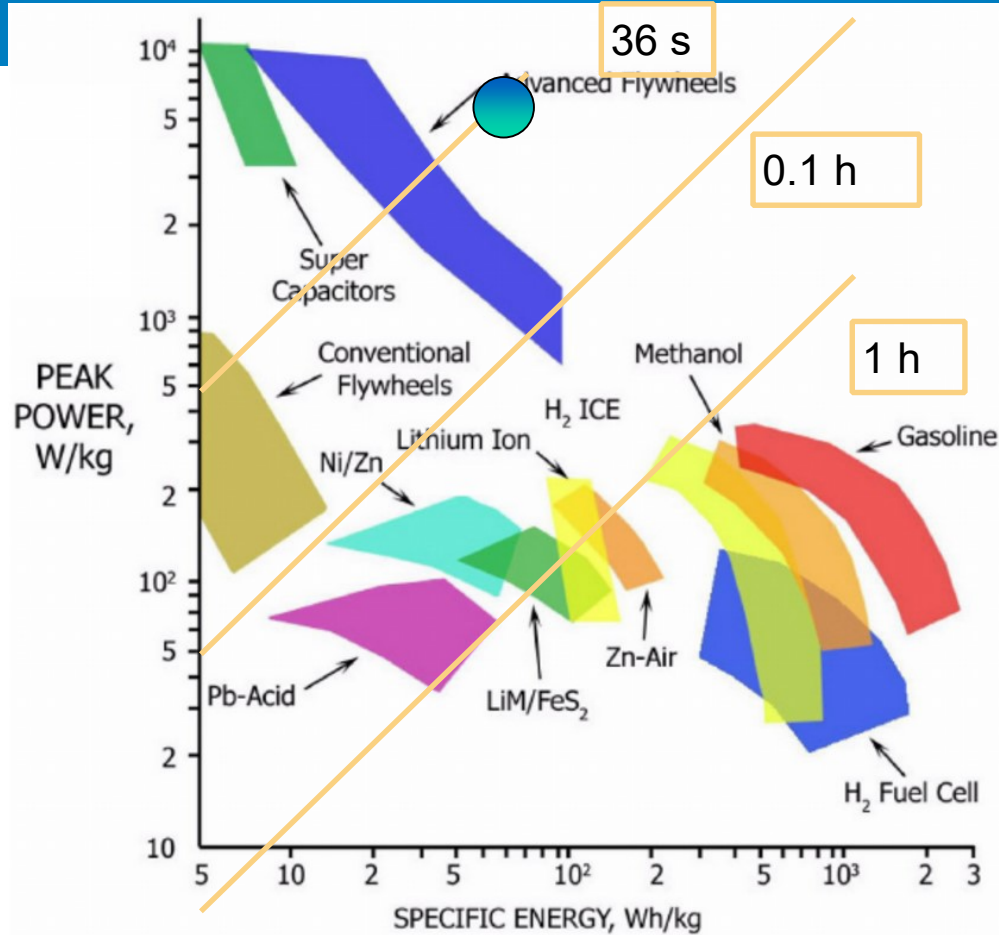
Business Case

Advantages of flywheels



**Power storage
vs.
energy storage**

 BNG flywheel
(rotor)



The physics

All about ONE equation



$$E = \frac{1}{2} I \omega^2$$

Where:

E is the stored kinetic energy (Joules)

I is the moment of inertia of the rotating mass (kg*m²)

ω is the angular velocity (rad/s)

Hoop stress limit on outer radius of rotating mass: $\sigma = \rho r^2 \omega^2$

This can be simplified to: $\frac{\sigma}{\rho} = v^2$

Material	σ/ρ (kJ/kg)
Steel	~200
GRP	~450
CRP	~1300

Flywheel Generations

State-of-the-art technology

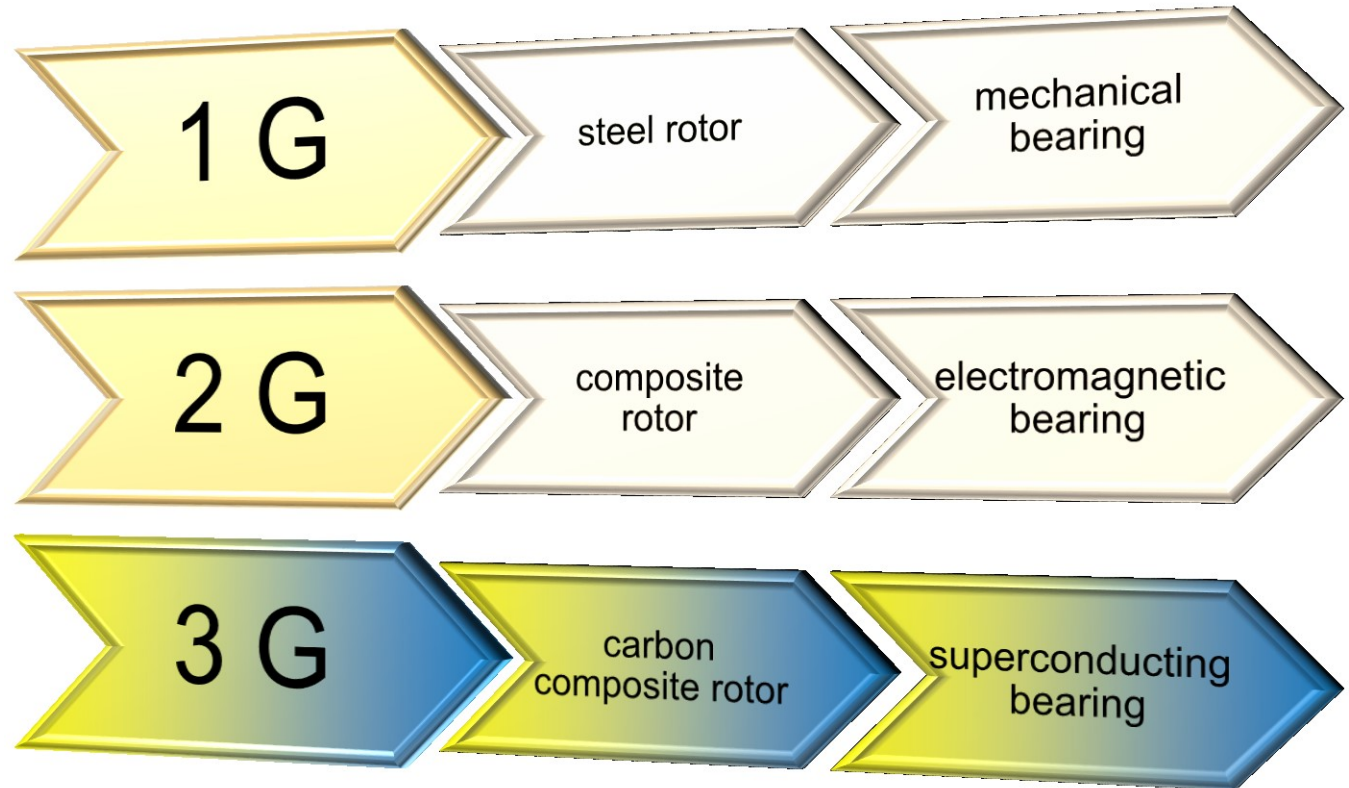


Progress

Considerable progress has been reached on:

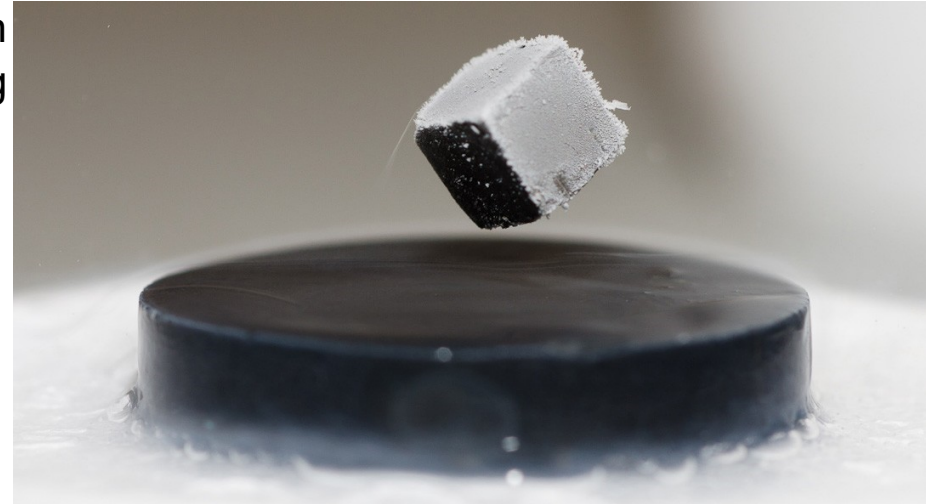
- Low friction bearings
- High strength carbon fibres
- Cooling technology

fostering 3 G flywheel technology



Superconducting is Better ...

The use of superconductors for levitation is known since long



Lexus just unveiled a working hoverboard ("Back to the Future", 2015)

Superconducting is Better

Advantages for Flywheels

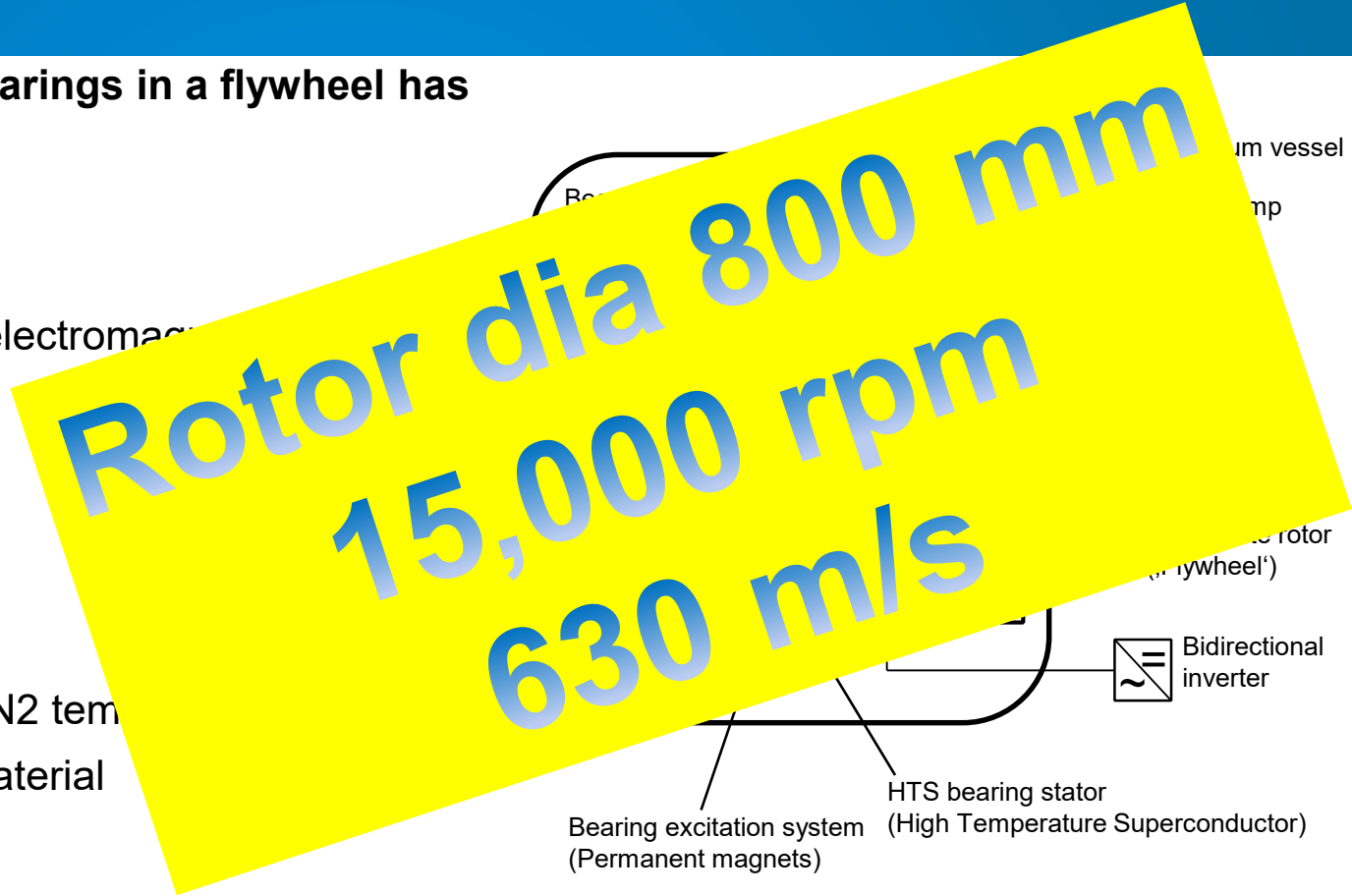


The use of superconducting bearings in a flywheel has the following advantages

- Low friction
- Self centering
- Passive control (compared to electromagnetic)
- Vacuum compatible
- High heat capacity

However this solution requires

- Cryogenic cooling at least to LN2 temperature
- Additional costs for the HTS material
- Integration to the system





Pictures from internet, published by google, facebook, etc.

UPS (Uninterruptible Power Supply)

Parameters

- Performance: 250 kW per unit
- Capacity: 2.5 kWh
- Maintain mains voltage for more than 20 sec. (until diesel generator starts)
- Improvement of power quality

Benefits

- No air conditioning and safety infrastructure
- Long life-time
- Low maintenance and operating costs
- Modularity and compactness



Application UPS

Advantages of flywheels



Flywheel energy storage for UPS systems

- Supplying power on demand
- Bridging time until generator start

Advantages

- High power in small foot-print
- Low stand-by losses
- System and charge status always transparent
- No degradation under cycling
- Can be combined with other functions (load levelling, ...)

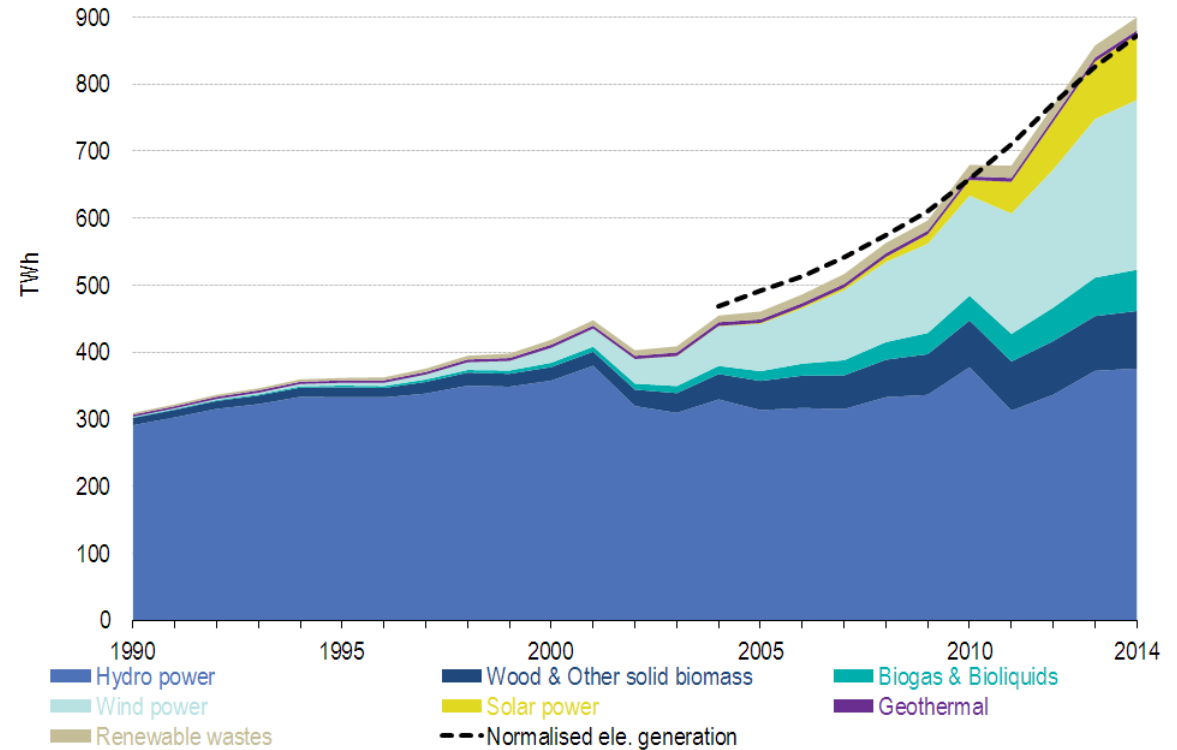


Energy Market & Storage



drastic changes in
the energy markets

new challenges
for grid stability



Eurostat: *Electricity generation from renewables
in the EU member states*

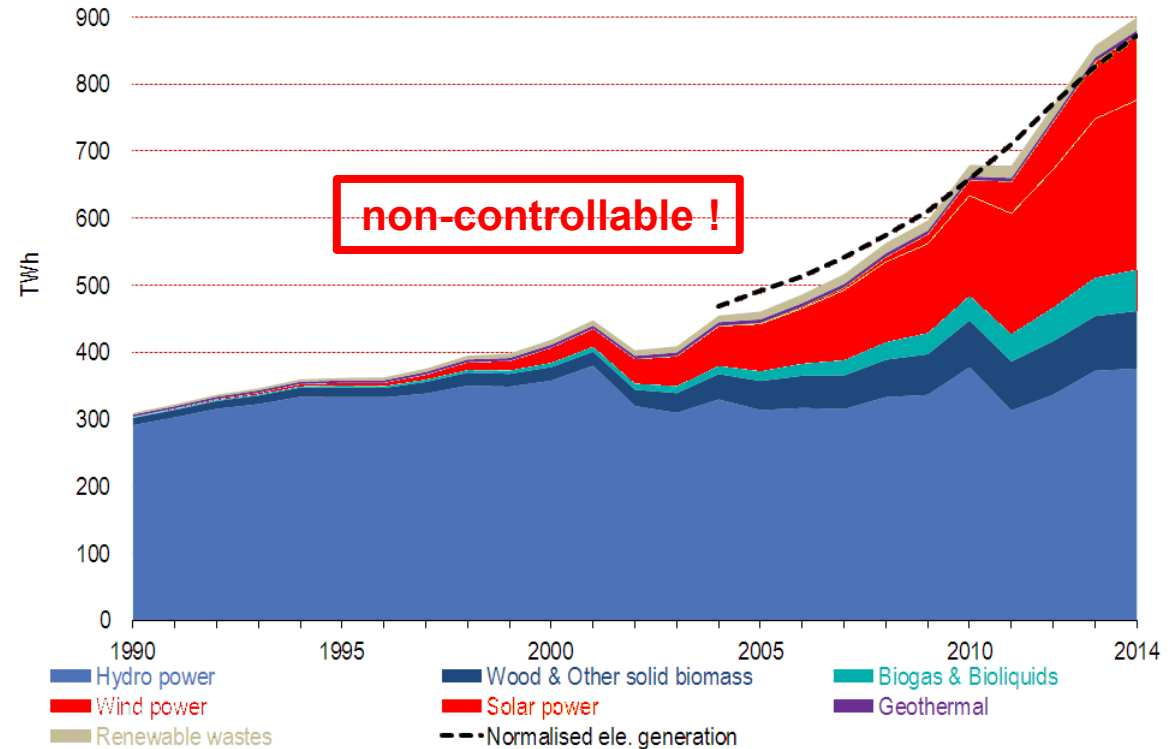
Energy Market & Storage

drastic changes in
the energy markets

new challenges
for grid stability

renewables:
distributed generation

imbalance supply – demand
tools for regulation needed



Eurostat: *Electricity generation from renewables
in the EU member states*

Parameters

- Performance: 500 kW per unit
- Capacity: 5-10 kWh
- Smoothing/buffering of renewable energy feed-in
- Grid stabilization and support at local nodes
- Power management in industry and public transport

Applications and benefits

- Renewable energy producers: Meet feed-in req. of utilities
- Grid operators: Installation of Flywheels avoid costly line upgrades
- Industry/transport: Reduce peak power consumption, enhance power quality, recuperation



Application Fast Cycling

Pictures during Assembly

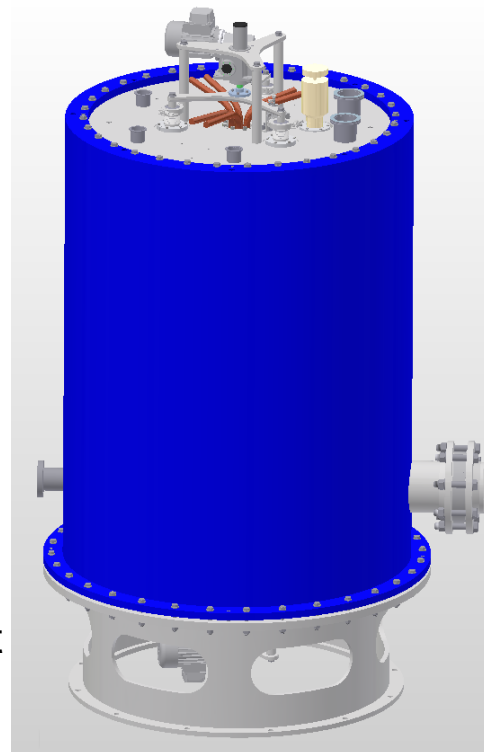


Flywheel energy storage for fast cycling systems

- Distributed / volatile / renewable generation
- Load levelling
- Peak shaving
- Recuperation (cranes, trains, ...)
- Island networks

Advantages

- High power in small foot-print
- Full real and reactive power capability
- System and charge status always transparent
- No degradation under cycling

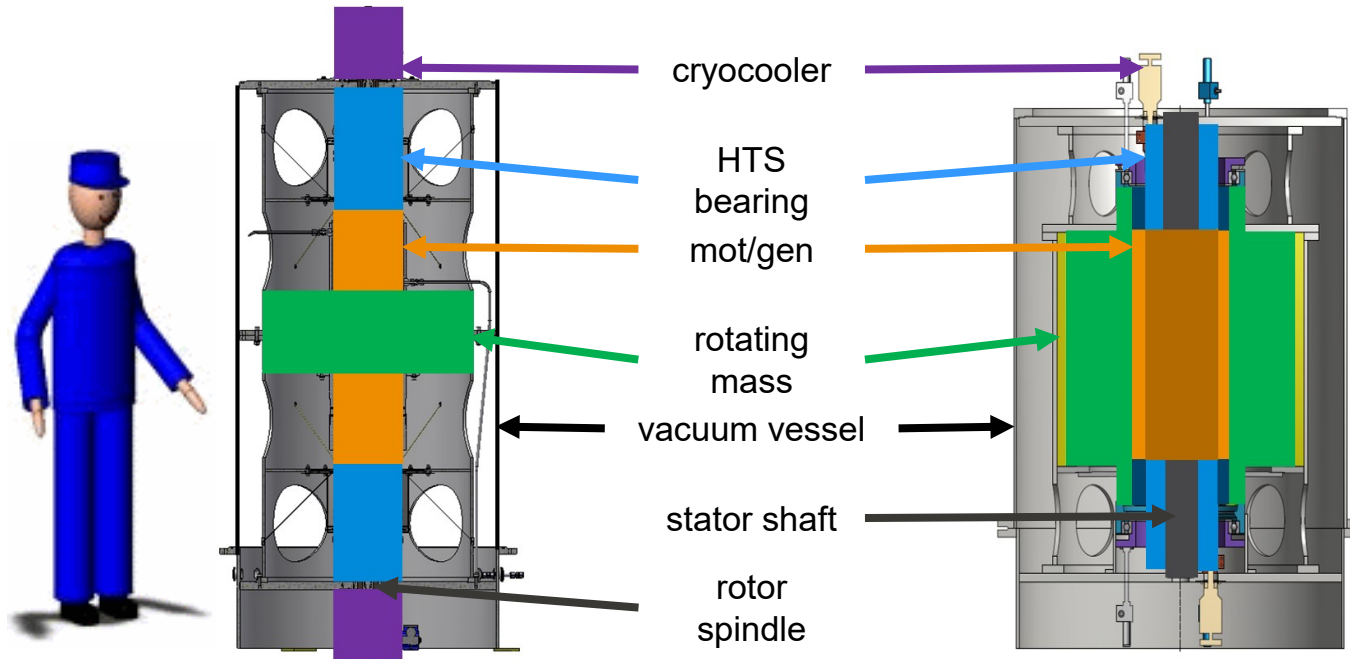


Grid stabilisation

- Frequency control
- Voltage control
- Spinning reserve
- Black start capability

Applications: UPS – Power Quality

Flywheel Design



- internal rotor
- two motors
- disc rotor

- external rotor
- one motor
- cylinder rotor

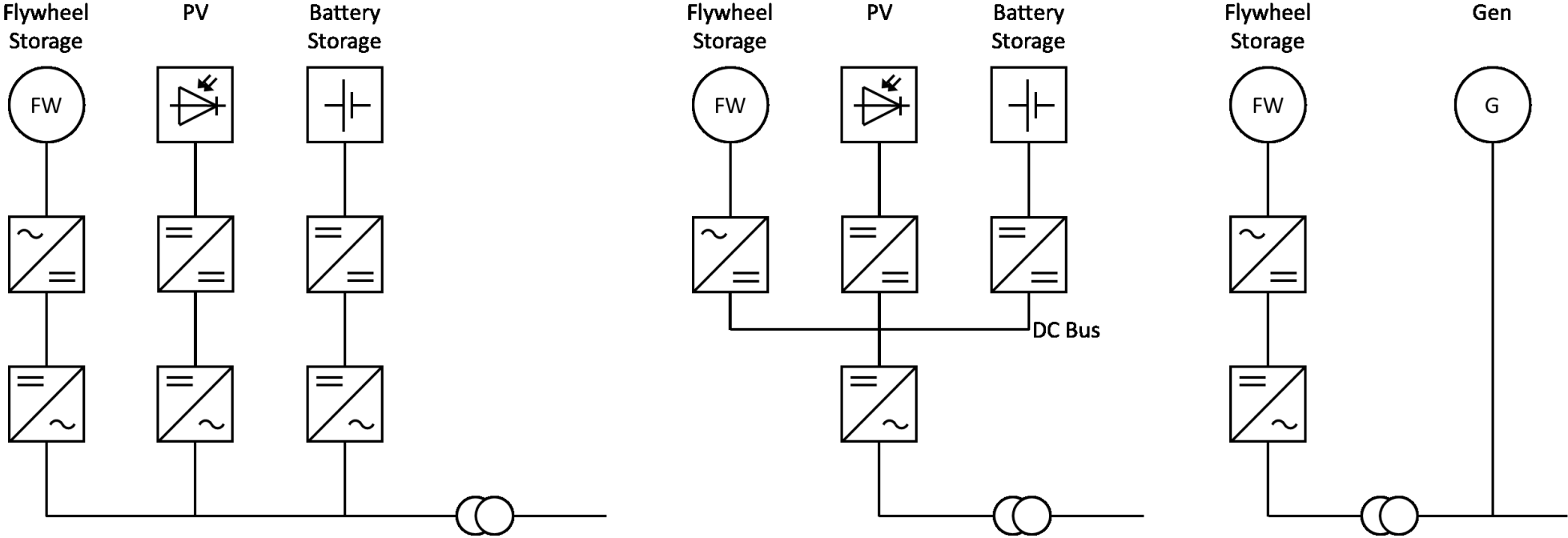
Applications: UPS – Power Quality

Outer View



UPS	Parameter	Power Quality
250 kVA	Power	500 kVA
2.5 kWh	Capacity	5 kWh
1.5 to	Weight	2 to
1.1 m	Diameter	1.2 m
2.3 m	Height	2.1 m
5%	Load cycles	50% - 100%

Examples of modular integration

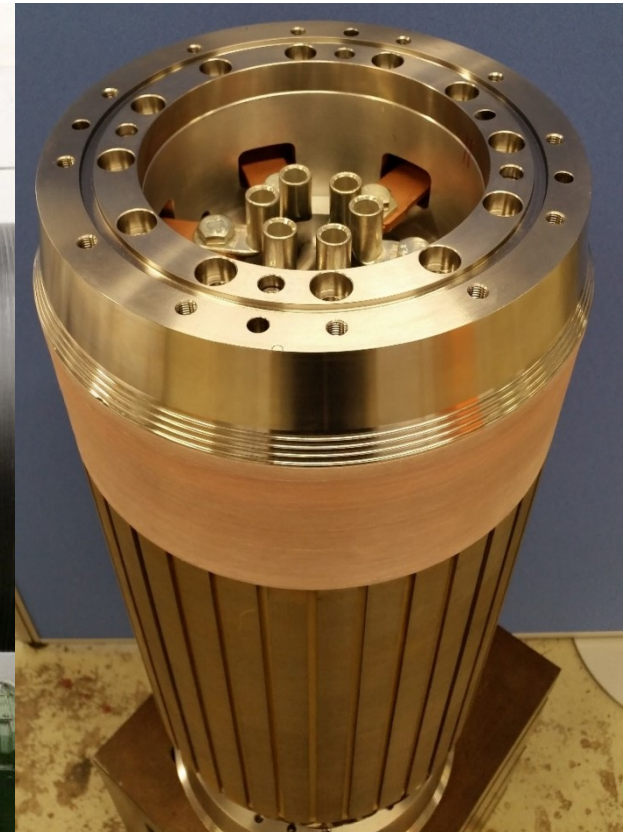


Impulse

High-speed Spinning Hackathon



- Which technological combinations will make sense
- Which “hot” markets have not been considered (enough)
- Any new ideas for superconducting technologies in flywheels
- ...
- ...



THANK YOU FOR YOUR ATTENTION and HAVE FUN



If you have questions please contact us at achim.hobl@bilfinger.com